CRYSTALLOGRAPHIC NOTES ON WAVELLITE FROM BOLIVIA, PENNSYLVANIA, ARKANSAS, AND BOHEMIA.

By Samuel G. Gordon.

Wavellite usually occurs as hemispherical or globular aggregates with a radiated crystalline structure, or very rarely as druses of minute crystals. The crystallographic data on the mineral are rather unsatisfactory due to the small size of the crystals heretofore found and their imperfect character. On the 1921 Vaux-Academy Expedition to the Andes, the writer obtained large slabs of beautiful prismatic crystals measuring up to 2 × 3 × 6 mm. This material forms the basis of this investigation. A study was also made of the other specimens of wavellite in the collections, with the measurement of crystals from Pennsylvania, Arkansas, and Bohemia.

Crystals of wavellite were first measured by Senff[1] from Frankenberg, Saxony. These showed the following forms: b (010), m (110), n (340), q (13.1.0), p (101), s (111), and o (121).

Des Cloizeaux[2] noted the following forms on wavellite from Montebras, France: b (010), m (110), n (340), s (111), and the doubtful form r (5.11.6).

Cesáro[3] described wavellite from Arbrefontaine, Belgium, with the forms b (010), a (100), m (110), s (111), o (121), and p (101). He suggested that the doubtful form r (5.11.6) of Des Cloizeaux was probably o (121).

Further examination of a crystal from Montebras by Ungemach[4] gave in addition the forms h (310), and l (430).

Ungemach also measured good crystals from Moore's Mill, Cumberland County, Pennsylvania,[5] which showed the combination b (010), a (100), m (110), l (430), i (320), h (320), o (121), and s (111).

Finally, Wherry[6] listed the following forms on crystals from Hellertown, Lehigh County, Pennsylvania: b (010), a (100), l (430), m (110), n (340), p (101), s (111), and o (121).

The axial ratios obtained by these writers are listed in Table I. A new value determined on crystals from Bolivia is given in Table II.

---

[1] J. Senff; Pogg. Annalen, 18, 474, 1830.
[2] A. Des Cloizeaux; Manuel de Minéralogie, II, 455, 1874.
[3] G. Cesáro; Mém. Acad. Roy. Belgique, 53, 28, 1896.
[4] H. Ungemach; Bull. Soc. Franc. Min. 35, 536, 1912.
[5] Erroneously given as Cly, York County, Penna., which was the site of the factory to which the mineral was shipped.
[6] Edgar T. Wherry; Proc. U. S. Nat. Mus. 54, 379, 1918.

TABLE I. AXIAL RATIO OF WAVELLITE

Date	Crystallographer	Locality	a	c	φ m
					o ′
1830	Senff	Saxony	0.5049	0.3751	63 13
1897	Cesáro	Belgium	0.5573	0.4084	60 52
1912	Ungemach	Pennsylvania and France	0.5577	0.4057	60 51
1917	Wherry	Pennsylvania	0.5640	0.4040	60 35

WAVELLITE, LLALLAGUA, BOLIVIA

The Llallagua tin mines are situated on the northeast slope of Cerro de Llallagua, about 100 kilometers southeast of Oruro, Bolivia. The deposits are phenomenal, and form the richest known mines of cassiterite. The ore bodies are distinct fissure fillings, or

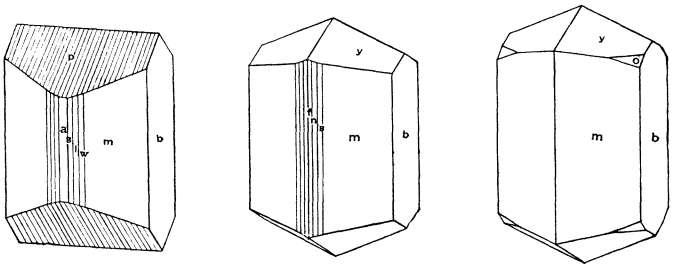

Fig. 1–3: Wavellite; 1. Llallagua, Bolivia; 2. Trimble's Mine, Chester County, Pennsylvania; 3. Hellertown, Lehigh County, Pennsylvania.

mineralized brecciated zones, in a quartz-porphyry which forms the core of the mountain. The principal metallic minerals are cassiterite, pyrite, wolframite, and bismuthinite.

The wavellite occurs locally in vugs in the quartz-pyritic portions of the veins. Frequently three generations of wavellite crystals are to be seen.

The crystals are colorless, the smaller individuals being quite limpid. The luster is vitreous, excepting on the unit prism m (110), which is pearly. The mineral also occurs at Llallagua in pale greenish stalactitic masses. The largest specimen in the Vaux Collections is a slab measuring 25 × 35 cm., and entirely covered with wavellite crystals. The crystals show the usual tendency to form subparallel aggregates, with distinct individuals in the cavities.

Preliminary measurements were made on twelve crystals, of which half were rejected due to subparallel growth present in the

crystals, or to poor reflections. The results of the measurements of the others are given in Table II.

The following forms were noted, (fig. 1): a (100), b (010), m (110) w (650), l (430), B (10.7.0), z (850), and p (101), of which w, B, and z are new. Their characters in brief are: a (100) exists as a very narrow face; b (010) is a large brilliant face which usually gives multiple reflections; m (110) is a wide pearly face, free of striations, and usually giving fair, bright reflections; w (650), l (430), B (10.7.0), and z (850) are line faces forming a striated zone between m (110) and a (100); p (101) is a wide, deeply striated dome, giving a series of multiple reflections, of which the ρ angle is fairly constant.

The average coördinate angles of m (110) and p (101) were used to determine the axial elements given at the top of Table II.

The cleavage of wavellite was given by Senff as parallel to p (101) and b (010) rather perfect; and by Des Cloizeaux as parallel to m (110) and b (101). The only cleavage noted by the writer was a very perfect one parallel to m (110).

TABLE II. WAVELLITE FORMS, LLALLAGUA, BOLIVIA

a : b : c = .5520 : 1 : .4067
po = .7365; qo = .4067

Letter	Form		Faces measured	Calculated		Measured		Signal
	Miller	Gds.		φ	ρ	φ	ρ	
				° ′	° ′	° ′	° ′	
a	100	∞0	7	90 00	90 00	89 52	89 48	Poor, faint
b	010	0∞	12	0 0	90 00	0 6	89 59	Fair, multiple
m	110	∞	21	61 6	90 00	61 6	89 52	Fair, bright
w*	650	$\frac{6}{5}$∞	2	65 17	90 00	65 24	89 57	Fair, faint
l	430	$\frac{4}{3}$∞	4	67 30	90 00	67 22	90 12	Fair, faint
B*	10.7.0	$\frac{10}{7}$∞	4	68 52	90 00	68 55	89 56	Poor, faint
z*	850	$\frac{8}{5}$∞	3	70 58	90 00	70 52	89 59	Poor, faint
p	101	10	12	90 00	36 23	90 1	36 23	Fair, multiple

New forms marked *

WAVELLITE, TRIMBLE'S MINE, PENNSYLVANIA

Trimble's mine is the famous locality for wavellite listed in the older books as "White Horse Station, Chester County." The old abandoned limonite pit so described is situated about a mile northwest of Planebrook Station on the Philadelphia and Chester Valley branch of the Philadelphia and Reading Railroad, in Chester

County. The mineral occurred in the form of white stalactitic masses of cryptocrystalline to crystalline structure, and occasionally in druses of very minute crystals.

A single crystal measuring $\frac{1}{8}$ by $\frac{1}{2}$ mm. was measured. The results are given in Table III. The following combination of forms was noted, fig. 2: b (010); m (110), B (10.7.0), N (210), f (520), and y (122); of which B, N, f, and y are new.

A crystal measured by Dr. Edgar T. Wherry[7] from this locality showed the following forms: b (010), a (100), i (320), l (430), m (110), n (340), p (101), and o (121).

TABLE III. WAVELLITE FORMS, TRIMBLE'S MINE, PENNSYLVANIA

Letter	Form		Faces measured	Calculated		Measured		Signal
	Miller	Gds.		φ	ρ	φ	ρ	
				° ′	° ′	° ′	° ′	
b	010	0∞	1	0 0	90 00	0 0	89 29	Poor, faint
m	110	∞	4	61 6	90 00	61 4	89 48	Fair, bright
B*	10.7.0	$\frac{10}{7}\infty$	1	68 52	90 00	68 54	89 53	Poor, faint
N*	210	2∞	1	74 33	90 00	74 43	90 00	Poor, faint
f*	520	$\frac{5}{2}\infty$	1	77 33	90 00	77 8	89 52	Poor, faint
y*	122	$\frac{1}{2}1$	2	42 9	28 45	45 29	28 38	Poor, faint

New forms marked *

WAVELLITE, HELLERTOWN, PENNSYLVANIA.

As noted above, crystals from the Hellertown locality, Lehigh County, were described by Wherry. As the material collected by the writer at this mine were different in habit from those already described, a single crystal, $\frac{1}{4} \times 1$ mm. in size was therefore measured. The results are given in Table IV.

The following combination was found b (010), m (110), o (121), and y (122). The dominant pyramid y (122) is a new form.

TABLE IV. WAVELLITE FORMS, HELLERTOWN, PENNSYLVANIA

Letter	Form		Faces measured	Calculated		Measured		Signal
	Miller	Gds.		φ	ρ	φ	ρ	
				° ′	° ′	° ′	° ′	
b	010	0∞	2	0 0	90 00	0 9	89 43	Fair, bright
m	110	∞	4	61 6	90 00	60 7	90 11	Fair, bright
o	121	12	4	42 9	47 39	41 56	46 37	Poor, faint
y*	122	$\frac{1}{2}1$	4	42 9	28 45	41 57	28 17	Poor, faint

New form marked *

[7] Private communication.

Wavellite, Moore's Mill, Pennsylvania

The wavellite from Moore's Mill, Cumberland County, Pennsylvania was described and figured by Ungemach. The locality is an abandoned wavellite mine about a mile south of Moore's Mill Station.

Two crystals were measured by the writer. The results are given in Table V. The following forms were noted: a (100), b (010), c (001), m (110), w (650), R (970), l (430), i (320), N (210), h (310), k (510), t (710), g (270), and o (121), of which c, w, R, N, k, t, and g, are new. The habit of the crystals is like those of Ungemach, and the new forms excepting g are line faces occurring in the striations between a (100) and m (110) of his figure; g is a line face between b (010) and m (110).

Table V. Wavellite Forms, Moore's Mill, Pennsylvania

Letter	Form		Faces measured	Calculated		Measured		Signal
	Miller	Gds.		φ	ρ	φ	ρ	
				° ′	° ′	° ′	° ′	
a	100	0∞	1	90 00	90 00	89 48	89 39	Poor, faint
b	010	0∞	2	0 0	90 00			
c*	001	0	2		0 0	0 0	0 0	Poor, faint
m	110	∞	8	61 6	90 0	61 12	89 47	Fair, faint
w*	650	$\frac{6}{5}$∞	3	65 17	90 0	65 37	89 42	Poor, faint
R*	970	$\frac{9}{7}$∞	1	66 45	90 0	66 44	89 42	Poor, faint
l	430	$\frac{4}{3}$∞	1	67 30	90 0	67 49	89 42	Poor, faint
i ?	320	$\frac{3}{2}$∞	1	69 47	90 0	70 14	90 0	Fair, faint
N*?	210	2∞	1	74 33	90 0	73 59	90 0	Poor, faint
h	310	3∞	1	79 36	90 0	79 31	90 16	Poor, faint
k*?	510	5∞	2	83 42	90 0	84 12	90 2	Poor, faint
t*	710	7∞	2	85 30	90 0	85 36	90 7	Fair, bright
g*?	270	∞ $\frac{7}{2}$	2	27 21	90 0	27 55	89 58	Poor, faint
o	121	12	1	42 9	47 39	42 10	47 9	Poor, faint

New forms marked *

Wavellite, Montgomery County, Arkansas

Montgomery County, Arkansas, is the most famous of the American localities for wavellite. It produced in abundance beautiful green radiating aggregates of the mineral in fissures in a sandstone. Frequently the radiations terminate in druses of small crystals.

A single crystal was examined, but gave very poor reflections. The forms noted were b (010), m (110), and p (101); the latter

was striated. The habit of the crystals is similar to that of Llallagua (fig. 1).

Crystals from the same locality measured by Dr. Edgar T.

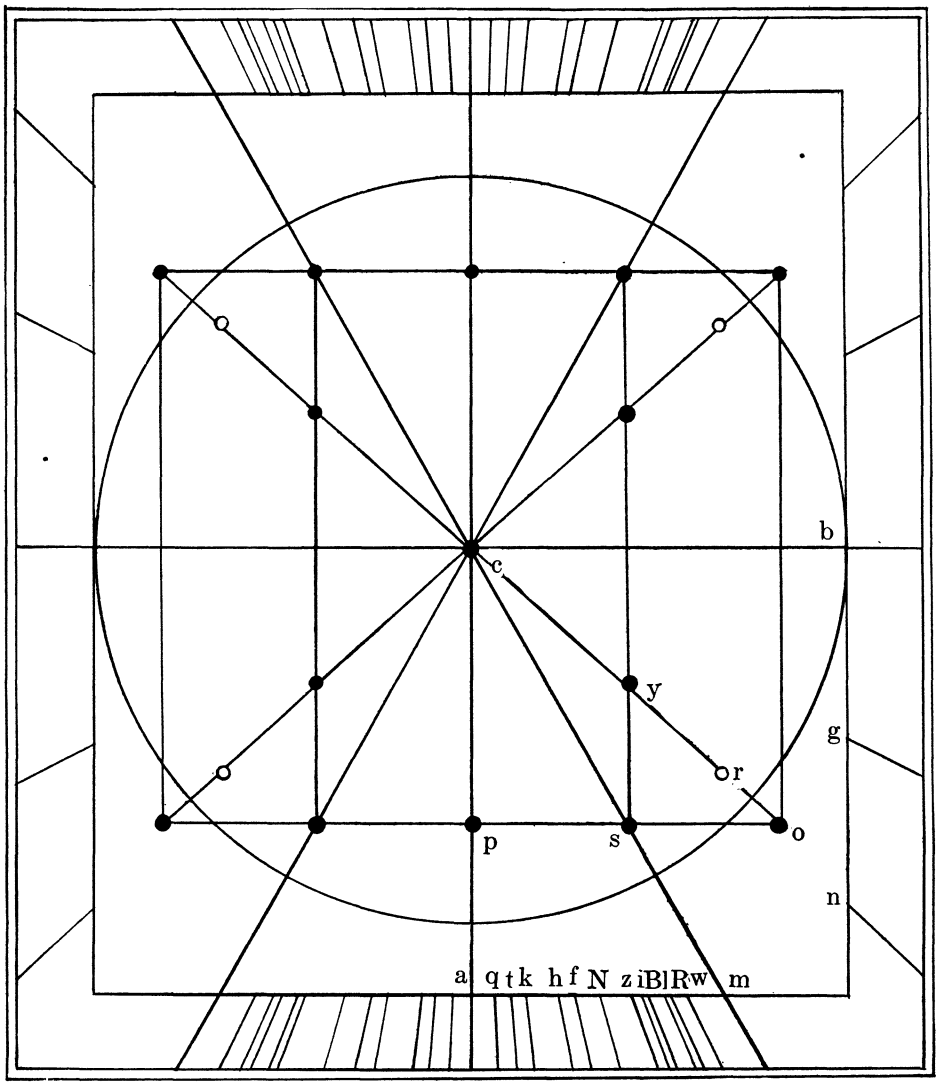

Fig. 4. Gnomonic projection of all wavellite forms.

Wherry[8] showed the following forms: b (010), a (100), h (310), l (430), m (110), n (340, u (130), p (101), and s (111).

Wavellite, Zbirow, Bohemia

A single crystal from a druse associated with radiations of the mineral from Zbirow, Bohemia, was measured. The faces were very dull, and gave poor reflections. The following forms were noted b (010), m (110), and p (101). The latter was not striated.

Table VI. Wavellite Angle Table

Orthorhombic; a : b : c = .5520 : 1 : 4067
p_0 = .7365; q_0 = .4067

Letter	Symbol		Calculated				Observer
	Miller	Gds.	ρ		φ		
			°	′	°	′	
c	001	0					Gordon
b	010	0∞	0	0	90	0	Senff
a	100	∞0	90	0	90	0	Cesaro
m	110	∞	61	6	90	0	Senff
w	650	$\frac{6}{5}$ ∞	65	17	90	0	Gordon
R	970	$\frac{9}{7}$ ∞	66	45	90	0	Gordon
l	430	$\frac{4}{3}$ ∞	67	30	90	0	Ungemach
B	10.7.0	$\frac{10}{7}$ ∞	68	52	90	0	Gordon
i	320	$\frac{3}{2}$ ∞	69	47	90	0	Ungemach
z	850	$\frac{8}{5}$ ∞	71	58	90	0	Gordon
N	210	2 ∞	74	33	90	0	Gordon
f	520	$\frac{5}{2}$ ∞	77	33	90	0	Gordon
h	310	3 ∞	79	36	90	0	Ungemach
k	510	5 ∞	83	42	90	0	Gordon
t	710	7 ∞	85	30	90	0	Gordon
q	13.1.0	13∞	87	33	90	0	Senff
n	340	∞ $\frac{4}{3}$	53	42	90	0	Senff
g	270	∞ $\frac{7}{2}$	27	21	90	0	Gordon
p	101	10	90	00	36	23	Senff
s	111	1	61	6	40	4	Senff
o	121	12	42	9	47	39	Senff
y	122	$\frac{1}{2}$1	42	9	28	45	Gordon
r?	5.11.6	$\frac{5}{6}$ $\frac{11}{6}$	39	28	44	0	Des Cloizeaux

[8]Private communication.